Overview Run-6 - RHIC

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RHIC Run-6 Timeline

- 1 Feb – Start of the Run-6. Start of the cooldown to liquid He temperatures.
- 12 Feb - End of cooldown and PS tests
- 5 Mar – Start of the $\sqrt{s}$=200 GeV Physics Run.
  Participating experiments: STAR and PHENIX.
  PHENIX – radial pol ; **STAR** – long pol
- 6 Apr – **PHENIX** – radial pol ; **STAR** – vertical pol
- 14 April –21 April – unscheduled shutdown (investigation of electric accident)
- 26 Apr – **PHENIX** – longitudal pol; **STAR** – vertical pol
- 10 May – **PHENIX** – longitudal pol; **STAR** – longitudinal pol
- 5 Jun – End of $\sqrt{s}$=200 GeV run
- 5 Jun-6 Jun, $\sqrt{s}$=22 GeV development
- 6 Jun – Start of $\sqrt{s}$=62 GeV Run.
  Participating experiments: STAR, PHENIX and BRAHMS
  PHENIX – longitudal pol; **STAR** and BRAHMS– vertical pol
- 20 Jun - End of $\sqrt{s}$=62 GeV Run.
- 20 Jun – 26 Jun. $\sqrt{s}$=500 GeV development
- 26 Jun - 30 Jun warm-up to liquid Nitrogen temperatures.
- 30 Jun - End of Run-6. (21.2 weeks of cryo operation)

Run-6 sub runs

Beam energy	100 GeV	11 GeV	31.2 GeV	250 GeV
Purpose	Physics operation	Machine test	Physics operation	Machine test
Time	12 weeks	1 day	2 weeks	1 week
Participating experiments	PHENIX, STAR		PHENIX, STAR, BRAHMS	

2005 Shutdown: Major Upgrades

- RHIC ring vertical realignment
- Additional NEG coating in warm regions, bringing total to 430m covered in the warm sections..
- Lattice for lower injection energy ($G\gamma=45.5$) to provide better polarization matching for AGS-to-RHIC transfer
- Multiple tools for the emittance measurement (polarimeter target, improved IPM, ATR line flags, jet luminescence monitor)
- BPM electronics upgrade
- New RampEditor.
- STAR detector shielding in the tunnel
- Injection kicker upgrade to provide shorter rise time.
- IR4 and IR8 cryostat measurements to understand the source of 24h orbit variations.

Physics run lattices

Beta* configuration (in meters):

	IP6	IP8	IP10	IP12	IP2	IP4
Injection	10	10	10	10	10	10
Store, 100 GeV	1	1	10	10	10	10
Store, 31.2 GeV	3	3	10	10	3	10

Lattice modifications:

- minimized excursion of dispersion function in IR6 and IR8 in the store at 100GeV
- decreased gamma_t lattice at the injection

Working points: (0.72-0.73) box at the injection; (0.68-0.695) box at the store
Tune swing done: 100GeV: at the very end of the acceleration, but before final beta-squeeze part of the ramp
31.2GeV: right before the last stone of the ramp

Machine setup

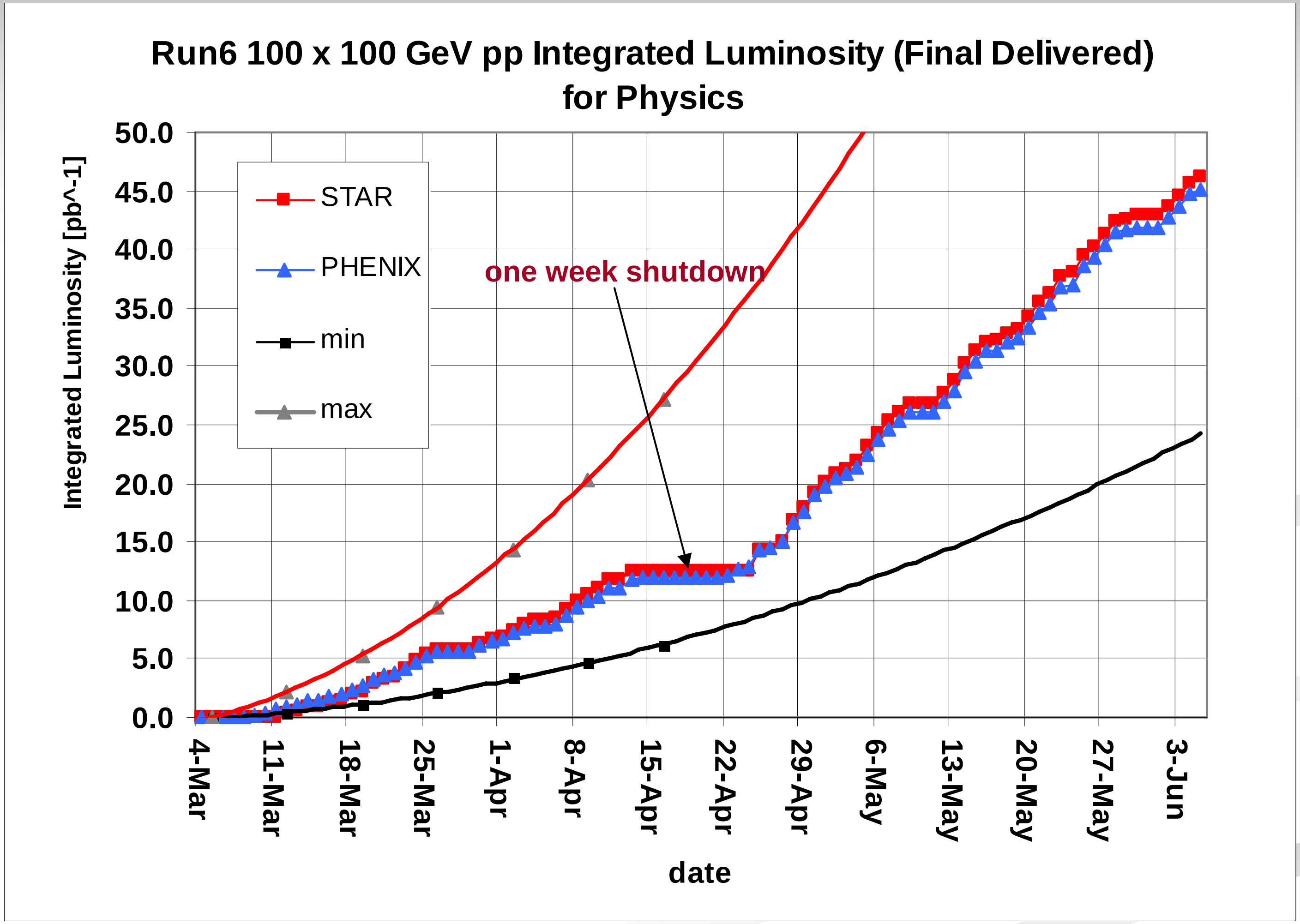
- Achieved in record 3 week time between end of the cooldown and the start of the Physics run.
- Even this period can be improved, taking account considerable machine downtime during the setup stage.
- Blue beam injection development and initial tune/decoupling feedback preparations were done already on the cooldown stage (after Blue ring was ready).
- Application of tune/decoupling feedback for the ramp development, from the very beginning.

  Beam delivered to the store on the second ramp attempt!

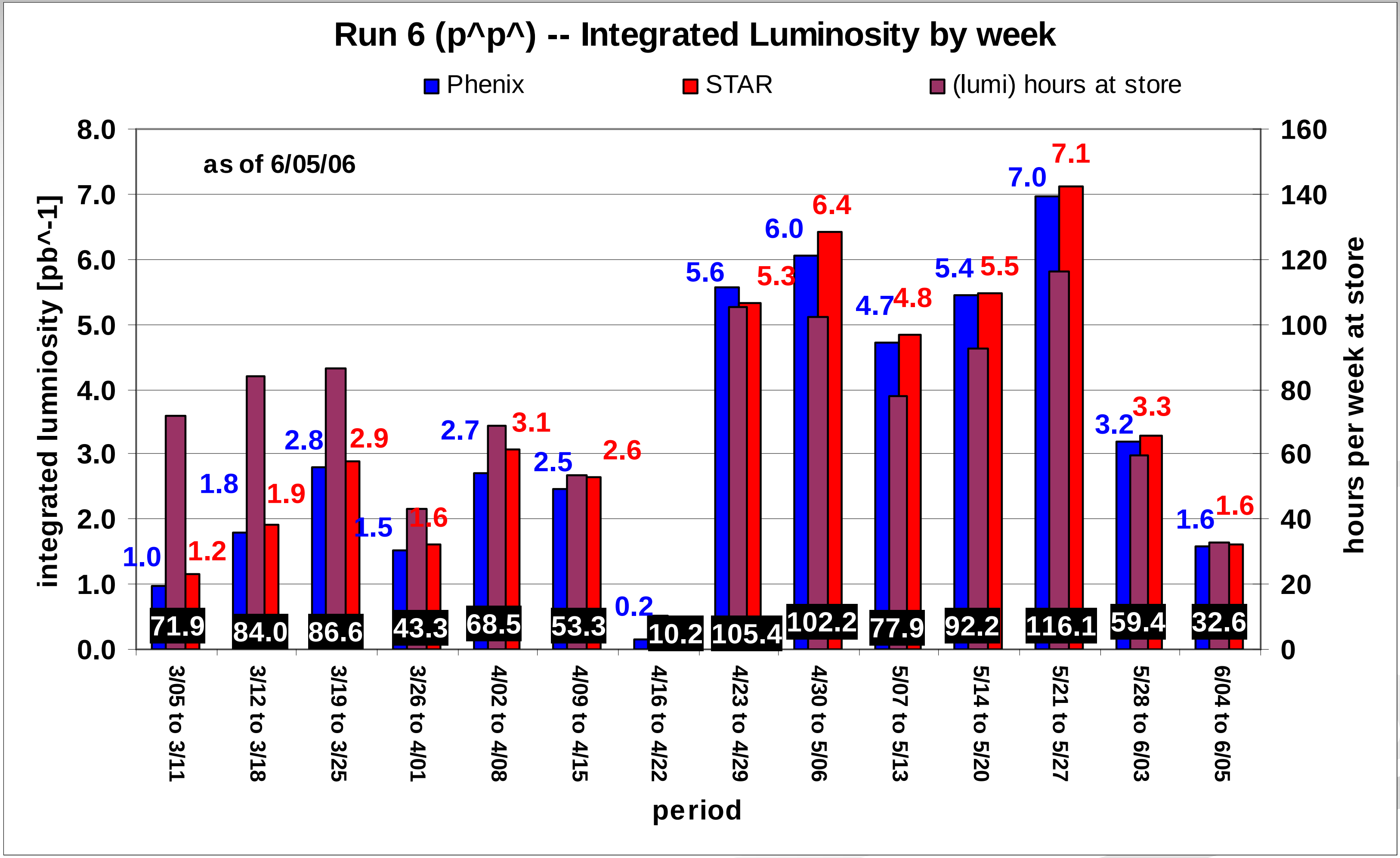
Polarized protons performance at 100 GeV

Parameter	Unit	2002	2003	2004	2005	2006
No. of bunches	--	55	55	56	106	111
bunch intensity	10^{11}	0.7	0.7	0.7	0.9	1.3
store energy	GeV	100	100	100	100	100
β*	m	3	1	1	1	1
peak luminosity	$10^{30}cm^{-2}s^{-1}$	2	6	6	10	**35**
average luminosity	$10^{30}cm^{-2}s^{-1}$	1	4	4	6	**20**
Collision points	--	4	4	4	3	2
average polarization, store	%	15	35	46	47	**60-65%**

Integrated luminosity; 100 GeV run

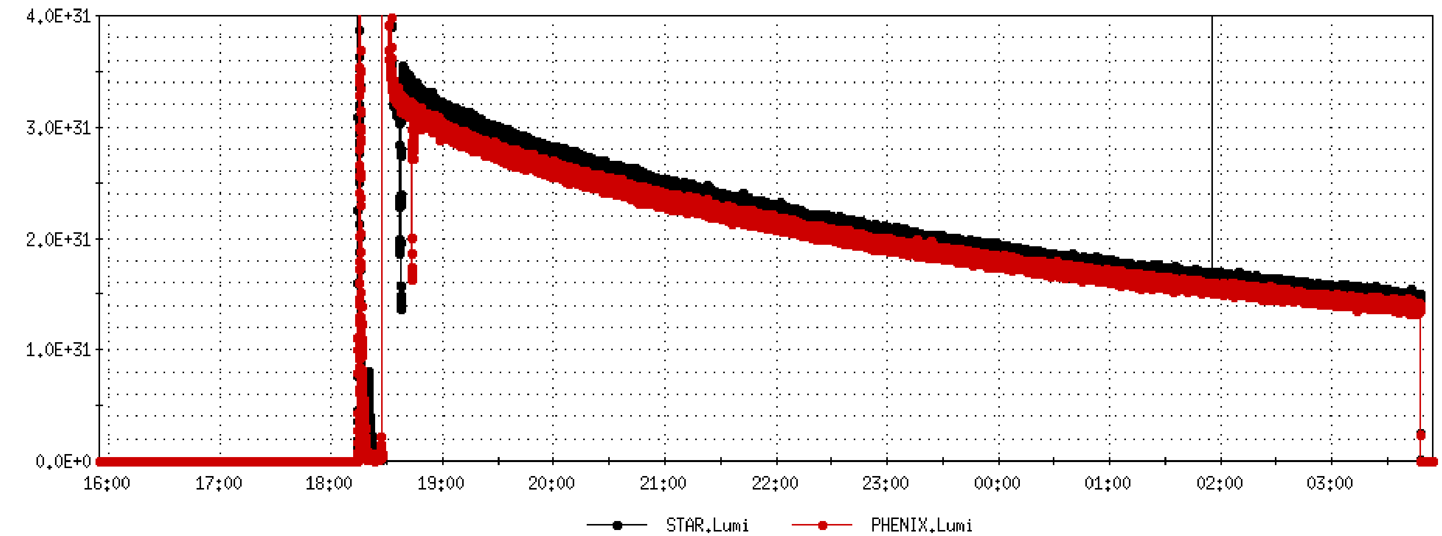


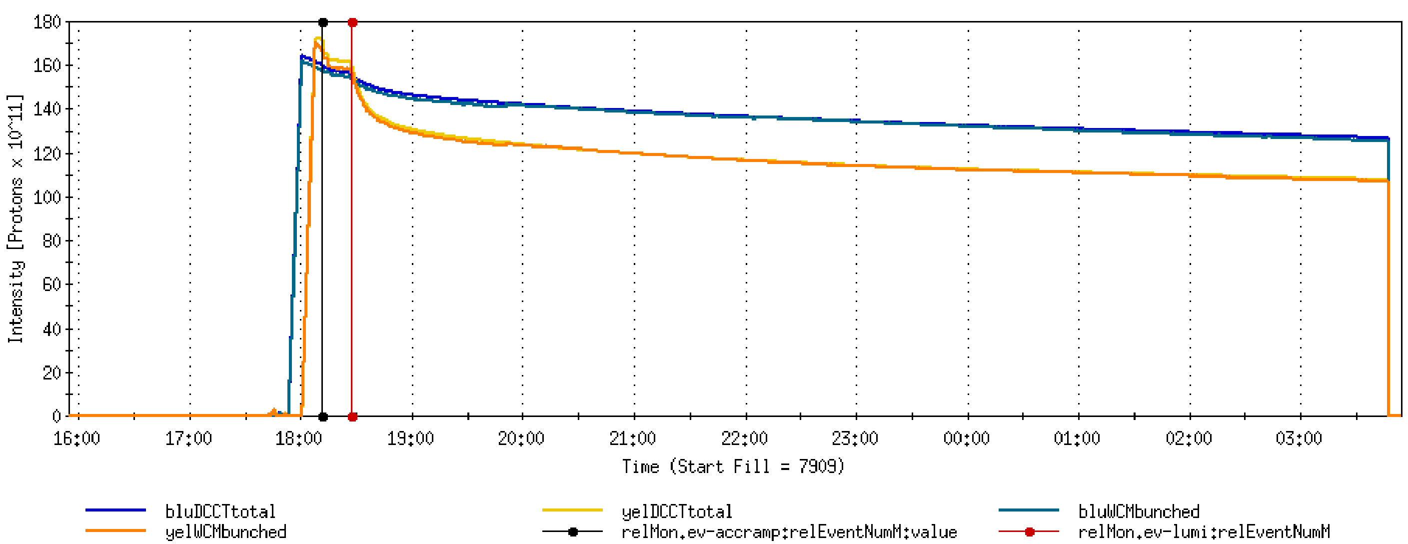
Integrated luminosity by week; 100 GeV run



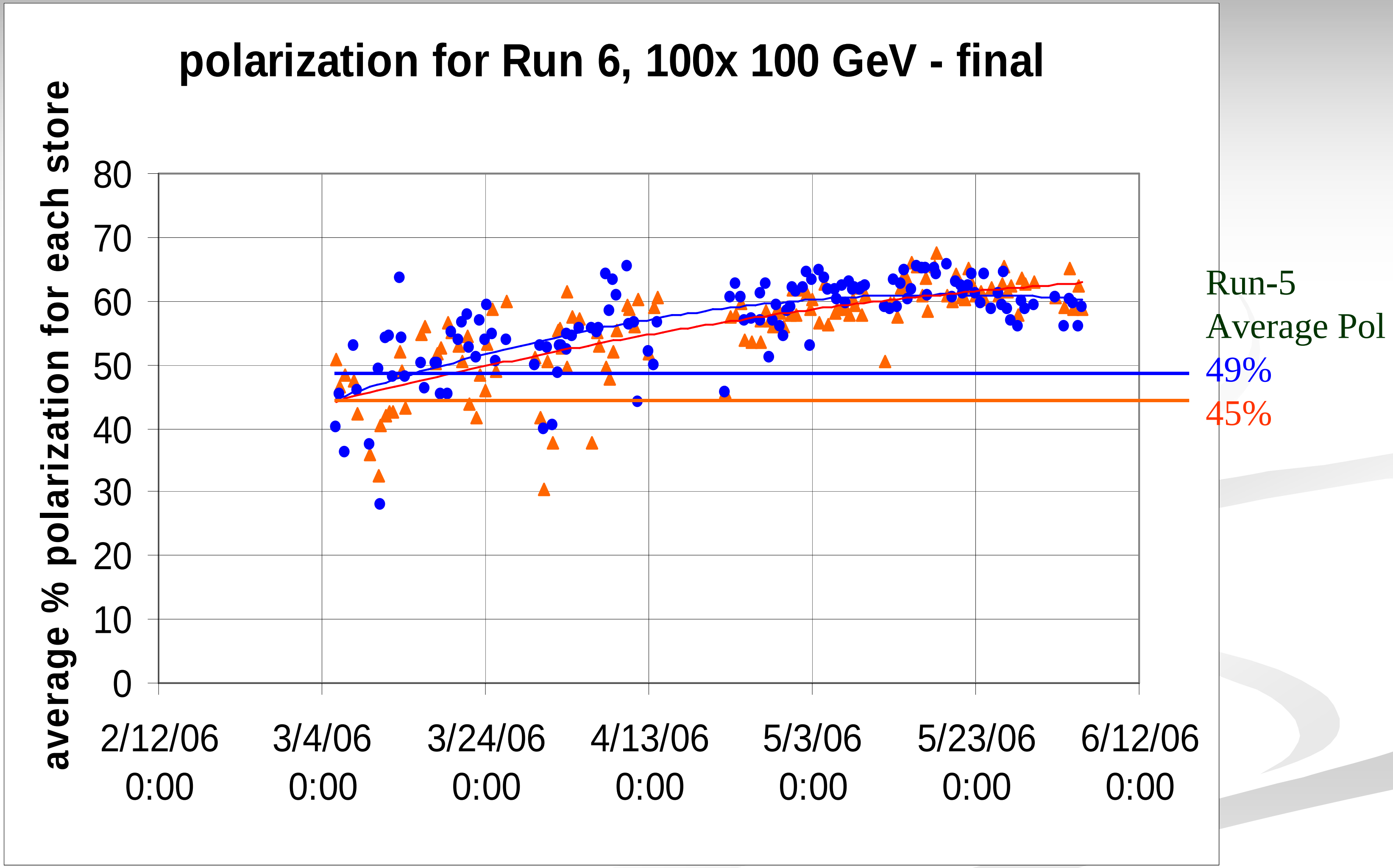
Golden store #7909 of 100 GeV run

Luminosity





Polarization during 100 GeV run



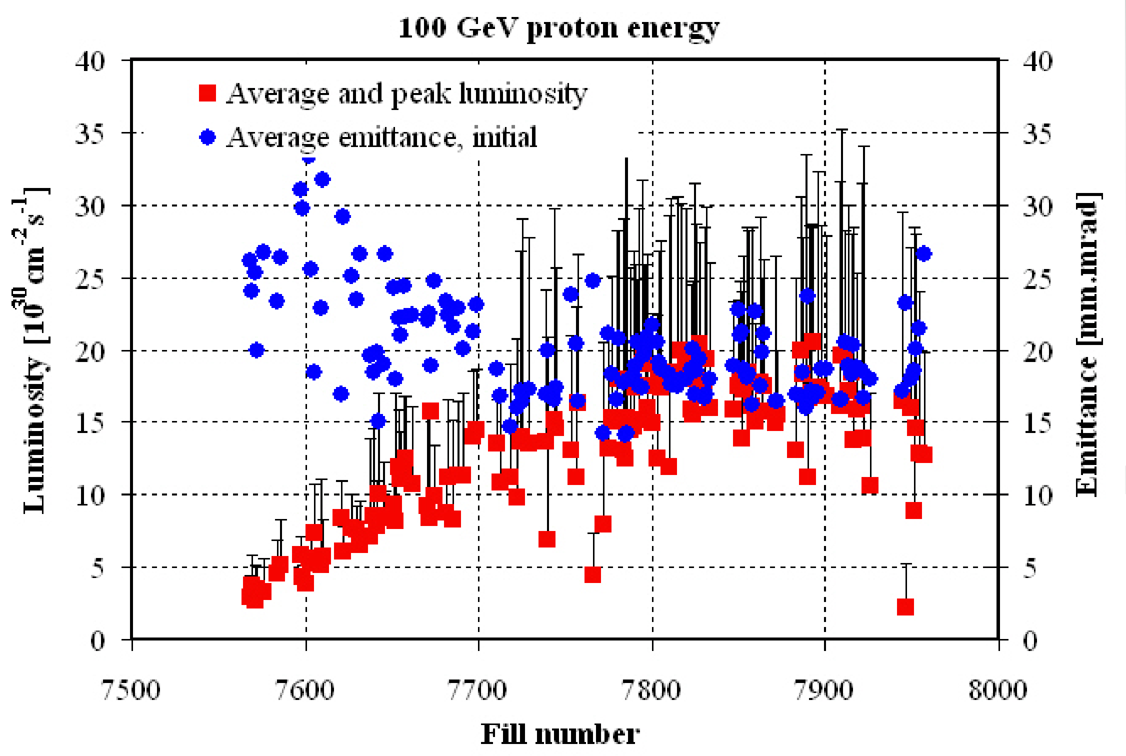
100 GeV run: Luminosities and transverse emittances

Improved transverse emittance control was important item at this run

During the run the improvements to achieve smaller transverse emittance were done both in the injectors and in the RHIC:

•appropriate choice of working point

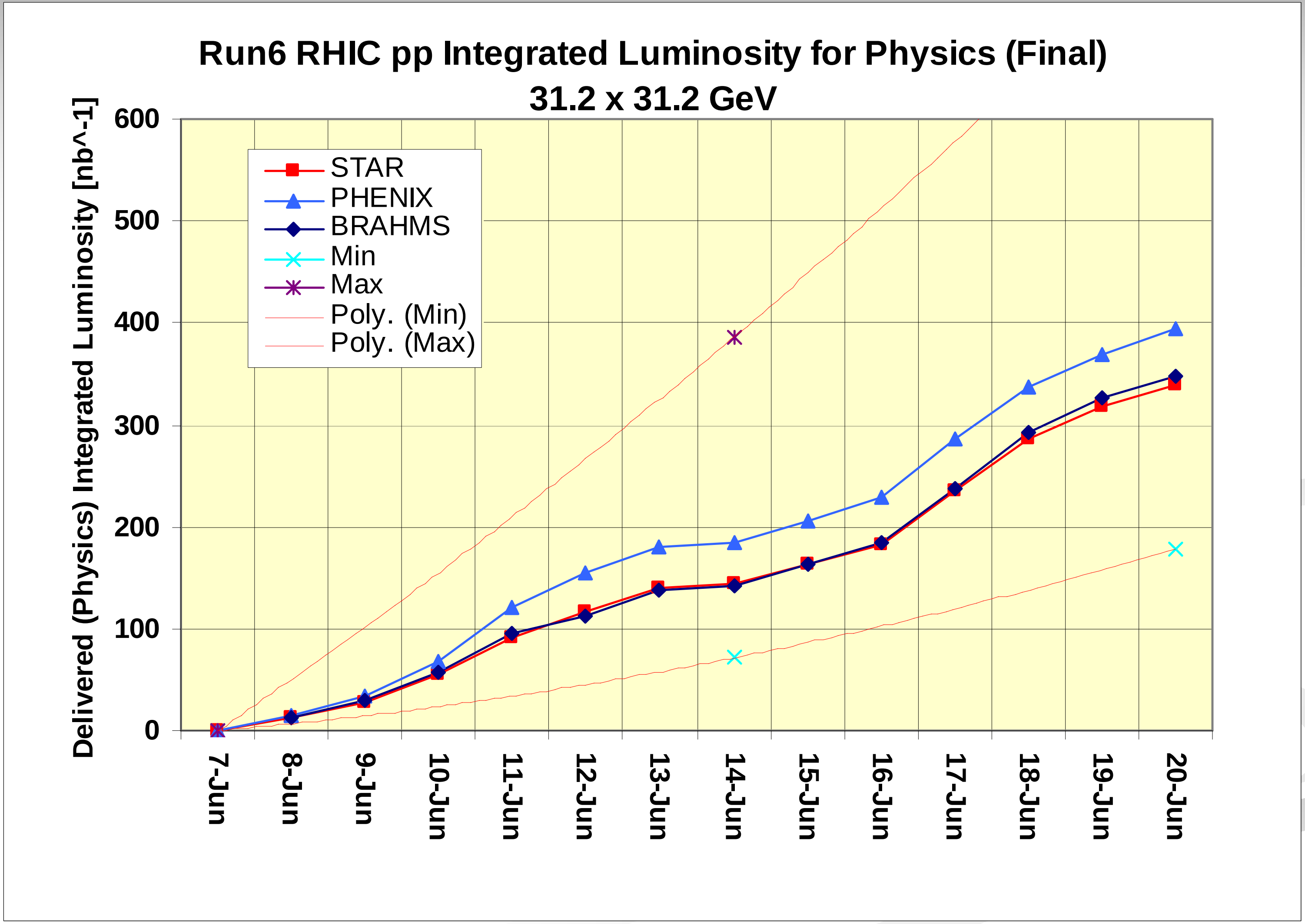
•avoiding short bunch length



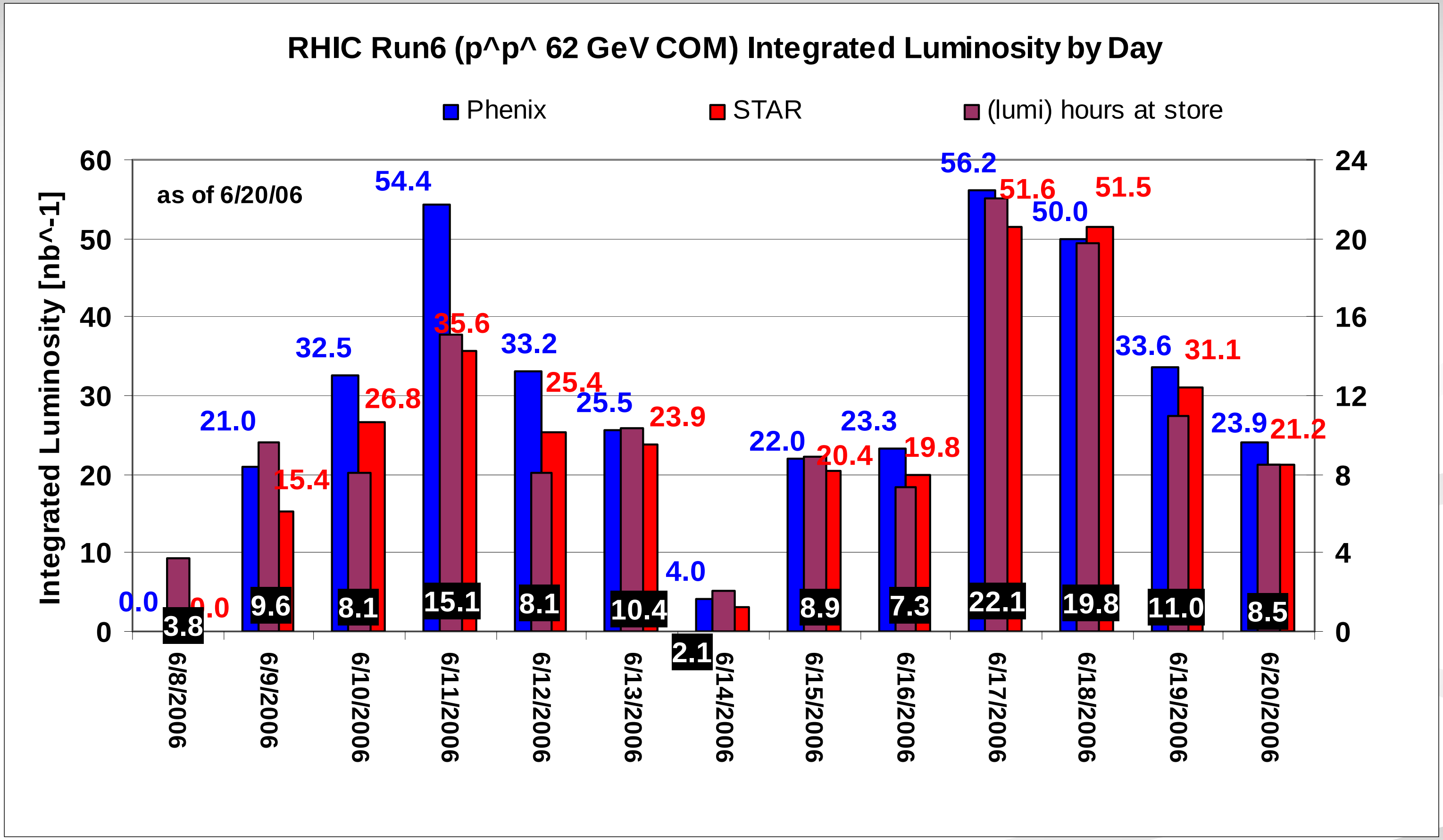
Luminosity improvement steps during 100 GeV run

- Improving (reducing) the emittance from the injectors.
- Increasing number of bunches (54 -> 111)
- Separating Blue and Yellow working points.
- Improving synchro loop, tightening longitudinal phase on the ramp.
- Switching Blue and Yellow working points.
- Increasing bunch intensity (from 1e11 to 1.5-1.6e11 in injected bunches)

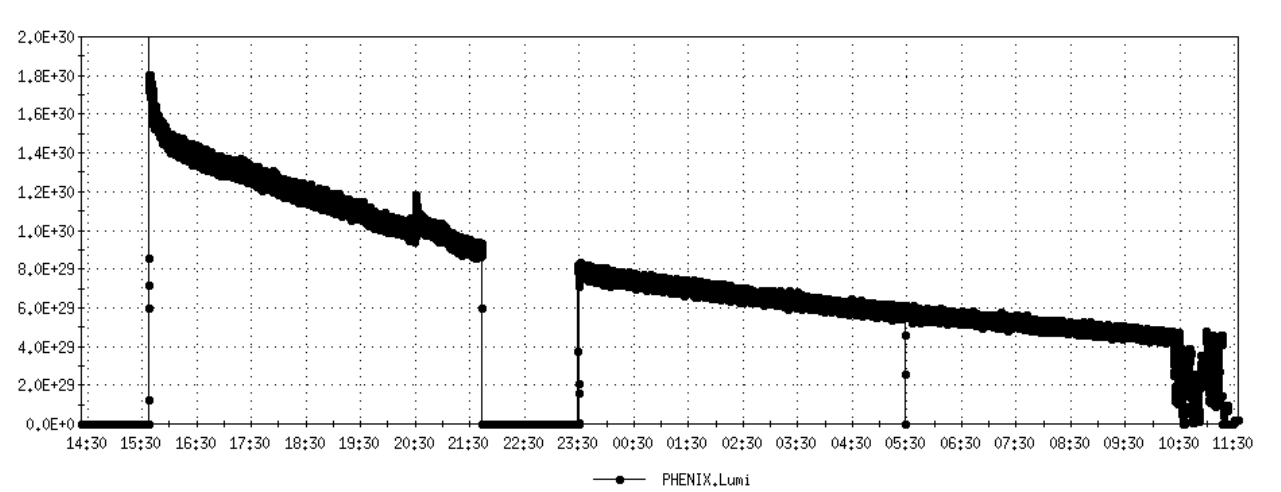
Integrated luminosity; 31.2 GeV run

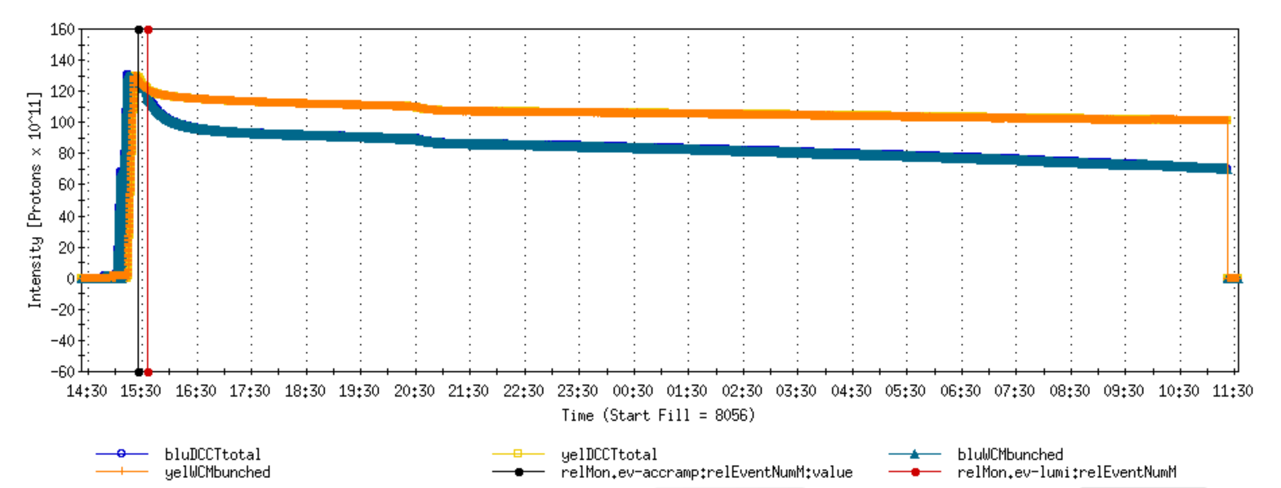


Integrated luminosity by day; 31.2 GeV run



Golden store (8056) of 31.2 Gev run, with rotators





Major operation achievements

- Successful application of tune/decoupling feedback for the initial ramp development.
- Fast collimation.
- Regular orbit correction at the beginning of the store (before the cogging) to provide the store reproducibility against 24h orbit variation.
- IR nonlinear corrections: used not only at the store but also on the ramp (after the beta-squeeze).
- 2/3 resonance correction
- Successful demonstration of “quad pumping” technique to provide better AGS-to-RHIC longitudinal emittance matching. Unfortunately, could not be effectively used because of the transverse emittance deterioration.
- Developed Beam Transfer Function measurement diagnostic.

Rotator and Snake setup

- Snake setup included:
  - Snake scans at the injection (on the machine set up stage)
  - Additional inner snake PS current scans to maximize polarization preservation during the Physics run.

- Rotator setup.
  - Rotator reconfiguration in several steps with beam in the store, making required orbit and tune correction.
  - Propagate the tune and orbit correction to the ramp. (Nevertheless further orbit correction was required in all stones of the rotator ramp.)
  - ~8h of beam work
  - Continued working point adjustments at the beginning of 2-4 following stores to achieve optimal lifetime.
- Rotator and Snakes control was included into the Ramp Editor.

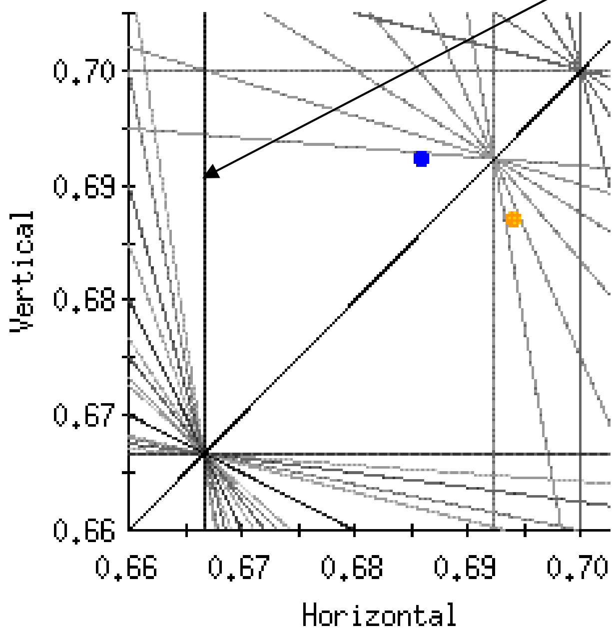
Factors limiting machine performance

- Store lifetime:
  - Q_x=2/3 resonance
  - beam-beam effects
  - large momentum spread
- Factors affecting transverse emittance:
  - small longitudinal emittance and higher beam intensity (enhanced electron cloud effect)
  - emittance increase on the ramp (?)
- Deterioration of ramp transmission with the beam intensity
- Beam oscillations with parasitic frequencies 10Hz, 60Hz, …

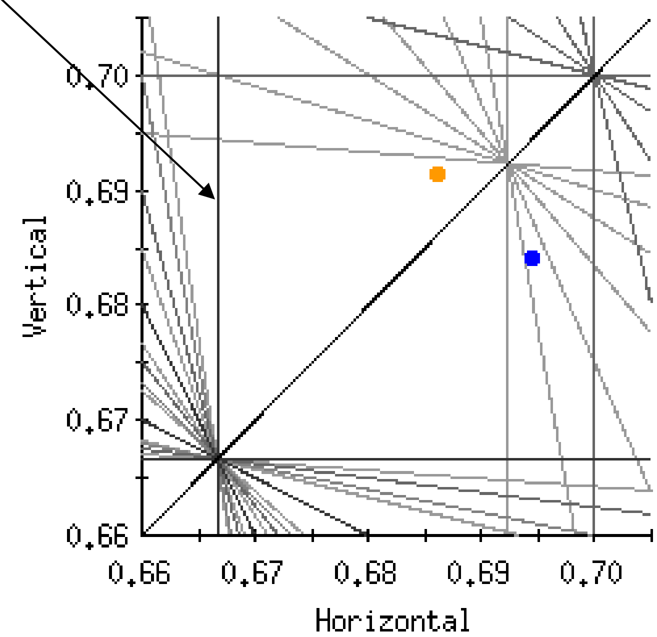
  (coming from cryo and power supply systems)

Store working points

Qx=2/3 most destructive resonance



Old setting



New setting

Some of the remaining operation issues

- <u>Reduce machine downtime, increase the time in the store.</u>

- PHENIX vertex reduction.

- Broken "Up" sequence, because of the need for the manual orbit correction.
- The same 'store' stone before and after the cogging. So, it should provide the good lifetime with/without collisions at different working points. (There is tune shift both due to beam-beam and the IR bump removal) .
- BPM offsets in some triplets are still large (>1mm).
- Model: tune/decoupling shifts versus orbit changes

Conclusions

- Congratulations with the successful run. Most of the goals were achieved.
- Thank you very much for your work during the course of the run.
- It would be necessary to improve the machine reliability, reduce the downtime, increase the time in the store.